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NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

OF THE

**COLLEGE OF AGRICULTURE AND
MECHANIC ARTS**

WEST RALEIGH

TWO IMPORTANT CANTALOUPE PESTS

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N. C. AGRICULTURAL EXPERIMENT STATION,

WEST RALEIGH, N. C.

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TWO IMPORTANT CANTALOUPE PESTS

The two insects dealt with in the following pages,—which will be spoken of as the pickle worm, *Diaphania nitidalis*, and the melon worm, *Diaphania hyalinata*,—represent in some respects the greatest obstacle to successful growing of cantaloupes, squash and cucumbers, and certain other cucurbitaceous crops mentioned elsewhere in this bulletin. Growers of these crops are obliged to prevent, or at least attempt to prevent, the work of such insects as cutworms, striped cucumber beetles, melon lice, squash lady beetles, and others, but as a source of injury to the maturing fruit, the two worms discussed in this bulletin are the chief offenders. The pickle worm, is, of the two, the most destructive. In the vicinity of Raleigh, where investigations have been made for the past two seasons, and over the greater portion of North Carolina, it is more injurious than the melon worm. The latter becomes more numerous and destructive in the coastal section and in States farther south. In Georgia and Florida, these two species are often of about equal importance. It would seem that the melon worm has about reached its northern range, as a destructive insect, in the latitude of Raleigh, but the pickle worm is fully as injurious here as it is in Florida.

For two seasons the writer has made a special investigation into the habits, development, life history and extent of injury caused by the melon worms and by the pickle worms. Most of the actual work and observations have been made in the vicinity of West Raleigh. The accompanying illustrations and descriptions should enable the general reader to distinguish between the two species, and the more intimate acquaintance with the work and habits of these worms, will, it is expected, enable growers to prevent some of the annual injury. It is seldom that any direct measures are adopted to prevent the work of these worms, or to prevent their increase. This condition should not exist. Growers of cucurbits should learn how to prevent or check the increase of these worms, even though it is impossible to exterminate them, or to prevent a certain amount of injury each year.

EXTENT OF DAMAGE IN NORTH CAROLINA.

By boring into ripening cantaloupes, cucumbers and summer squash, pickle worms injure these crops to an extent ranging from a small per cent up to nearly total destruction, depending greatly on the season and whether the crops are maturing early or late.

An early-maturing crop of cantaloupes or cucumbers, that is, one harvested before July 1, is not often seriously injured by pickle worms, no matter how numerous they become later in the season. On the other hand, a late July or early August crop may be nearly ruined even around Raleigh, while in the coastal section these insects

become numerous somewhat earlier in the season. In the cantaloupe section of Robeson and Scotland counties, some injury occurs when the crop is gathered later than July 10, as was true in 1910. If the season had permitted earlier planting and earlier maturity, the worm injury would not have amounted to two per cent of the crop. In 1910, it often went as high as fifteen to thirty per cent. Around Raleigh, where most of the cantaloupes in 1910 were not gathered until August 1 or later, the worms in some instances destroyed seventy-five per cent, and in a few fields, nearly the entire crop.

The above statements refer particularly to the injury caused by the pickle worms. The other species, known as the melon worms, have not been numerous enough during 1909 and 1910 to prove a serious pest, for when present, they occurred mainly on the foliage of summer squash or boring in the late squash. The writer has seen only a few of this species that were actually boring into cantaloupes and cucumbers around Raleigh, and in squash they were present only late in the season when the crop was of little value.

The actual loss caused by these worms is, therefore, largely dependent on the season, but the writer's observations have shown that the grower can practice methods of rotation, use of squash as a trap plant, and the destruction of remnants of an infested crop, and thereby reduce the injury considerably, and prevent the annual increase of these pests.

OBJECT OF INVESTIGATION.

The study of these two cucurbit worms was undertaken for the purpose of attempting to learn some method of preventing more effectively, than it has been done in the past, the usual amount of injury. It was hoped that the melon worms, *D. hyalinata*, would be made the principal object of study because previous literature has not dealt largely with that species. Fortunately, however, this form has not been destructive in the vicinity of Raleigh during the past two seasons, nor is it liable to become so if parasites continue to reduce its numbers, as they have done in the past. The present bulletin will therefore be confined largely to a statement of what has been learned concerning the habits and development of both species, and mention of predaceous and parasitic enemies. Methods of preventing the work of these worms are fully explained.

PICKLE WORM.

Diaphania nitidalis, Cramer.

REASON FOR COMMON NAME.

A study of the early mention of this insect shows that the name "pickle worm" was first bestowed on it by Riley in 1869 because the worms were then frequently found in pickled cucumbers, as they

were being cut for the table. For many reasons this title is not appropriate, for there is scarcely a farmer who knows it by this name, and its usual method of damaging cantaloupes and summer squash would far better call for the name "melon borer." However, since the name pickle worm has been used in literature for so many years, it seems best to retain it. There is still another good reason for retaining this common name, and that is, in order to distinguish it from the other species described in this bulletin as melon worm, *D. hyalinata*. The latter species could much more appropriately be called the striped melon worm, but it seems inadvisable to try to change these names after they have been used for so many years.

FOOD PLANTS AND FEEDING HABITS.

Pickle worms probably feed on nearly all cucurbits, but in North Carolina they work mainly on cantaloupes or muskmelons, summer squash, cucumbers and gourds. Quaintance has observed it on the watermelon, but the writer has never seen a single larvæ on that crop, even though watermelon fields, immediately adjoining cantaloupes in which the worms were very numerous, have been frequently examined. It, therefore, seems quite certain that this worm seldom attacks the watermelon. The pickle worm does not appear to have been recorded in America as feeding on any plants not belonging to the cucurbitaceous family. It certainly does not often cause noticeable injury to any crops except the few mentioned above.

On cantaloupe, squash and cucumber, pickle worms feed freely in the opening bud clusters, in the blooms—particularly large squash blooms,—in fruit of all sizes, and also in the main stem and leaf stems. While the buds, blossoms and fruit are abundant, the worms, if they are not overly numerous, will seldom go into the leaf stems or stalk. Late in the season when the plants are through fruiting, a large number are often found in the main stalk and leaf stems, where their work resembles that of the common squash vine borer, *Melittia satyriniformis*. The favorite feeding place for pickle worms is undoubtedly in the large blooms of summer squash (Fig. 16), or in the unopened buds. Late planted squash and cucumber often have the vines thoroughly riddled and practically killed by pickle worms. The leaf and blossom buds are devoured before they can open, and as these usually furnish insufficient food, the worms burrow in the stems, in which they eat long cavities.

When working on cantaloupe vines, pickle worms are frequently found in the buds and blooms, in which they sometimes become nearly full grown. The real injurious feeding, however, is in the maturing fruit of squash, cantaloupe and cucumbers, which may be considered as the most important crops. Small pickle worms usually make shallow cavities in the rind, but sometimes bore directly through the rind and feed on the interior. The larger worms usually

bore directly through the rind, and one worm may make several entrance holes. (Fig. 1.) In the green fruit the worms are content



FIG. 1.—Pickle Worm injury to ripening cantaloupes. Photographed in natural position in field. (Original.)

to feed on the interior, but in a ripening cantaloupe they seem to dislike the soft flesh and consequently make several entrance holes or excavate large cavities in the rind. Every one who has grown cantaloupes knows that the fruit soon sours or rots after a worm has made a hole sufficiently deep to allow the air to enter.

According to practically all published records, pickle worm injury seems to be confined to cantaloupe, muskmelon, cucumber, squash, cashaw and cymilins. Pumpkins seem to be exempt from injury, according to Quaintance, who records pumpkins in Georgia as not infested even when growing adjacent to muskmelons that were eventually destroyed.

HISTORY AND DISTRIBUTION.

The pickle worm moth has been known since 1782, when it was listed by Cramer. In 1794, Fabricius gave its habitat as Austria. It seems, however, that this is an American species. The injurious character of the larvæ seems to have been first recorded by Walsh and Riley in the *American Entomologist*, in 1869, when it was found injuring cucumbers at Alton, Illinois, Peeverly, Missouri, and St. Joseph, Michigan. During that year the fact that the larvæ were frequently found in pickled cucumbers, was what led Riley to suggest the name pickle worm.

This insect has been reported as occurring in Canada, the United States, West Indies, and in parts of South America. In the United States it occurs in nearly all the South Atlantic and Gulf States, and as far north as New York, and westward through Kansas. It is

probably present also through Central America and Mexico. The first illustrated account of the pickle worm is doubtless that given by Riley in his Second Report on Noxious Insects of Illinois, pp. 64-70. At that time considerable injury seems to have been caused by the larvæ to both cucumbers and muskmelons over a large territory. In his article, Riley states that "The worms commenced to appear in the latitude of St. Louis about the middle of July, and they continued their destructive work till the end of December." In another sentence he said that he could find no previous mention of its destructive work, and that it evidently was never destructive enough in the past to attract attention.

In the Report of the United States Commissioner of Agriculture for 1870, Glover figured and mentioned this species briefly. Snow in 1876 reported it as not common in Kansas, and Packard in 1877, French in 1878 and Comstock in 1879, gave this insect brief mention. Since 1883, numerous writers (see bibliography) have made mention of the occurrence and destructiveness of this pest in various parts of the country.

Throughout the North the pickle worm is not often numerous enough to be injurious, but in the South, particularly in the Carolinas, Georgia and Florida, it causes considerable injury every season. Very few cucurbit fields are ever entirely free from this pest in North Carolina and States southward, during the months of summer and fall.

DESCRIPTIONS.

Eggs. (Fig. 2.)

Freshly deposited eggs are of a pearly white color, but change to yellowish after about twenty-four hours, and to a deeper yellow before hatching, when the shape of the larva is easily detected through the nearly transparent shell. The surface of the shell is faintly marked with raised, irregular lines forming four, five and six-sided areas. The shape of the eggs varies greatly, dependent on the surface on which they are deposited, and on the number of eggs laid in the masses, which vary from two to six or seven. Eggs are seldom placed singly. Single eggs measure about 0.8 mm. long by 0.4 to 0.6 mm. wide. They hatch during warm weather on the fourth day.

Larvæ. (Fig. 3, a and b.)

The description of the larval stages, after each molt, as originally written by Quaintance,¹ has been found by the writer to be correct and is therefore reproduced without any changes.

Larva, First Stage.—Length, 1.6 mm.; in shape, sub-cylindrical; head relatively large. Color of body, uniformly whitish; ocelli brownish black; tubercles and corneous areas, spiracles and mandibles, brownish; tips of mandibles darker, strongly toothed. Head subcordate, 0.25 mm. wide, by 0.22 mm. long; protho-

¹Ga. Sta. Bul., 54.

racic shield moderately distinct; thoracic legs well developed, terminating in blade-like spine. Prolegs normal, well developed, with circle of 9 or 10 well-

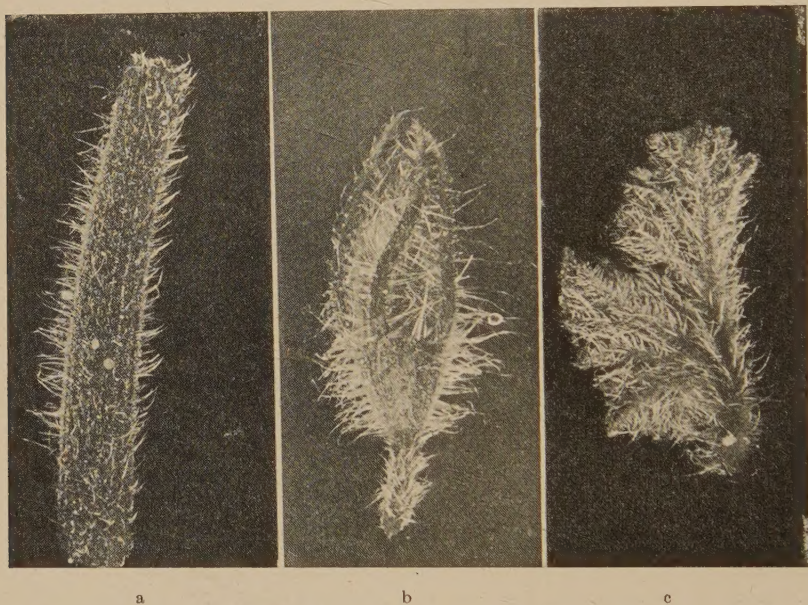


FIG. 2.—Egg masses of the pickle worm attached to the plant hairs of summer squash. (a), 3 masses on leaf stem; (b), 1 mass on young bloom bud; (c), 1 mass on young leaf. Magnified $2\frac{1}{2}$ times. (Original.)

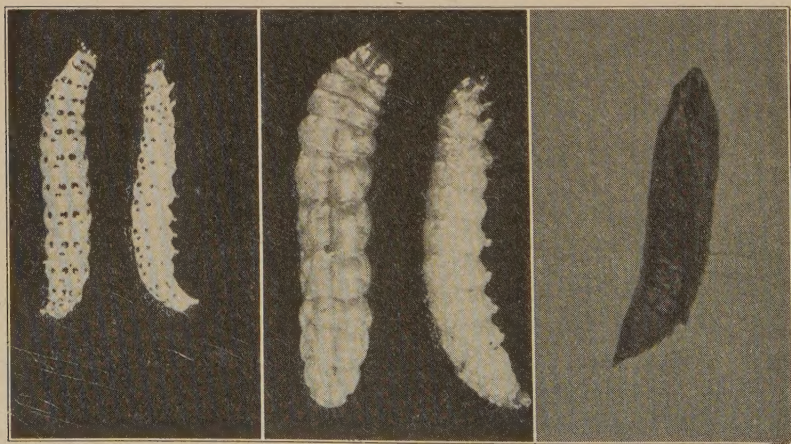


FIG. 3.—Pickle Worms and Pupa. Two worms on left, as they appear before fourth molt; in center, worms nearly ready to pupate; pupa on right. Magnified $2\frac{1}{2}$ times. (Original.)

developed hooks. Anal prolegs present, normal. Setae arising from moderate tubercles which are surrounded by more or less well-defined corneous areas. On third abdominal segment, tubercles I, III and IV, and spiracle in almost straight dorso-ventral line. Tubercle II, ventro-caudad of I, to which it is nearer than

III. Tubercles IV and V approximate, though in distinct corneous areas. Tubercle VI, absent. Tubercle VII, with normal position, composed of two somewhat separated setæ. Tubercle VIII, present, on inner side of proleg. On body segments 3, 7, 9 and occasionally 2, setæ arising from Tubercle III, on each side, very long. Setæ on abdominal segments dorsad of spiracles, on each side somewhat spatulate at tip; ventrad of spiracular line setæ acute. Setæ of Tubercles II, V, and cephalic one in VII, but moderately long.

Second Stage.—Length, about 2.5 mm.; body tapering slightly caudad and cephalad; color of body whitish, the large corneous areas surrounding tubercles distinctly brown and more or less circular. Head light brown; ocelli dark brown; prothoracic shield and mandibles brown. Tubercles as in stage I, except VI, which is now present, about equidistant between IV and V, and VII. Tubercle VII, now with three setæ. In IV and V, the brown corneous areas have coalesced, though the setæ are not closer together than in First Stage.

Third Stage.—Length about 4 mm. Head about 0.81 mm. wide, by 0.64 mm. long, subcordate, brownish. Ocelli, mandibles, margin of prothoracic shield, and corneous areas of body, brownish black. In this and the Fourth Stage, the brownish black or black corneous areas occurring in more or less transverse rows, across the body, give such a conspicuous marking that any one should be able to distinguish larvæ of this species from those of *Diaphania hyalinata*. The larvæ of this latter species have two longitudinal subdorsal whitish lines and are of a pronounced greenish color; these larvæ, also, are more slender, and considerably more active when disturbed, wriggling out of a leaf, much like larvæ of the grape leaf folder (*Desmia Maculalis*).

Fourth Stage.—Length about 10 mm. Head about 1 mm. wide, by 0.96 mm. long; rather squarish, though with deep V-shaped indenture above. Body, void of food, whitish in color. Corneous areas, large, rounded, shiny black; prothoracic shield margined with black. Setæ as in previous stage.

Fifth Stage.—(Immediately after fourth moult.) Length about 15 mm. Head 1.6 mm. wide, 1.6 mm. long, sub-circular. Color of body, whitish; the distinct black transverse spots of earlier stages are lost in the fourth moult, and these, in the last stage, take a faint brownish tinge, scarcely noticeable in contrast to the color of the body. Spines and tubercles as in earlier stages.

Full Grown Larva.

A full grown pickle worm, as taken gorged with greenish colored food, is greenish to yellowish green in color, and measures from five to seven-eighths of an inch in length. The feet and prolegs are lighter, with claws of feet brown. Head and prothoracic shield yellowish brown, with mandibles and ocelli dark brown. The skin is somewhat transparent and the pulsations of the dorsal tube or "heart" may be plainly seen along the back. Larvæ vary somewhat in color from whitish to yellowish or greenish, depending on the amount and character of the food matter within them. Many larvæ, after leaving the food preparatory to pupation, assume dorsally a dull, coppery color—others retain the normal coloration.

Cocoon.

Preparatory to pupating the full grown worm spins a scanty white silken lining in the fold of some leaf, usually on the wilted or dying foliage. In this shelter they assume the pupal stage.

Pupae. (Fig. 4.)

The pupa is at first pale green, but soon become rather uniformly brown, with leg and wing shields lighter. If partly exposed to the light they become very dark brown. The head end is bluntly pointed, while the caudal end is acute and bears a group of strong,

short spines, curled at the tips, which serve to hold the pupa in its cocoon. The length of the pupa varies from one-half to nearly three-



FIG. 4.—Pickle Worm Pupæ. Above, view of pupa from left side; below, partial view of ventral aspect. Magnified nearly 7 times. (Original.)

fourths of an inch. Fig. 4 shows their general shape and appearance. In this stage under average summer conditions they remain between eight and nine days, or all winter if they represent the last generation.

Adults. (Fig. 5.)

The adult is a somewhat striking-looking moth. The wing expanse varies from one inch to nearly one and one-fourth inches, and the length of the head and body, including the brush terminating the abdomen, is nearly five-eighths of an inch. The general color above, of body and wings, is yellowish brown, with an iridescent purplish reflection. The front wings show an irregular semi-hyaline area of a yellow tinge, situated somewhat nearer the tip than the base. On the hind wings the inner two-thirds is of the same semi-transparent yellow tinge. These markings are well shown in the illustration. The lower surface of the wings shows the same markings, but the brown color is less brilliant. The thighs and breast are silvery white, while the lower side of the abdomen and the legs are more of a tawny color. The antennæ are very slender and nearly as long as the body. The eyes are brownish-black. The prominent labial palpi are brown laterally and silvery white beneath. In both sexes,

the abdomen terminates in a prominent brush formed of flattened, more or less curved scales which are yellowish near the base and darker toward the tip. This brush can be partially withdrawn so that it is not conspicuous. In the female the brush is smaller and



FIG. 5.—Pickle Worm Moth. Magnified $2\frac{1}{2}$ times. (Original.)

the individual scales flatter and more curved than in the male. In other respects the sexes are difficult to distinguish, except when the female is heavy with eggs.

EGG LAYING AND HATCHING OF EGGS.

Eggs are laid at night, probably after midnight, since the moths seldom fly before that hour. Clusters of from two to four eggs, occasionally six or seven, are usually placed on buds, flowers, terminal stems, and tender portions of the foliage, although they have been observed on older leaves when the plants are scarce. The writer has never seen them on the fruit of cucurbits. Many of the eggs are attached to the plant hairs, as shown in Fig. 2, in which case the eggs often look as though they had been impigned over the point of the hair. They are often so situated on the large plant hairs of the stems and buds of summer squash, and when so situated the egg mass assumes a globular shape. In other cases the eggs are placed loosely among the plant hairs and are often laid in flat masses on the surface of the leaf or stem. The eggs do not appear to be glued and can be dislodged without injury in most instances.

Shortly before hatching, which occurs when the egg is about three and a half to four days old, movement of the strong, dark mandibles of the larva can be seen through the egg-shell. For an hour or more before the larva emerges these jaws are frequently working in

an attempt to cut through the shell. When an opening is made it is enlarged until the thoracic legs can be thrust out to gain a foothold and then the larva sometimes crawls out in a minute or two, or may slowly emerge while taking frequent rests. In masses of several eggs one may be hatched four or five hours before the last.

LARVAL DEVELOPMENT AND HABITS.

The larvæ immediately after emerging from the egg shells crawl rapidly about if confined on a small area not suitable for food, but soon commence to feed when a suitable place is found. They pay no attention to the empty egg shells. Before feeding they usually clean and straighten out the hairs scattered over the body by drawing



FIG. 6.—Pickle Worm Injury. Three squash buds on left; on right, very young squash cut open to expose worm within. Slightly reduced. (Original.)

them between their mandibles. Within a few hours after hatching the little larvæ may be completely buried in the soft tissue of the bud or fruit on which they commence to feed. Only a comparatively few reach the fruit until after they are a few days old and have passed at least the first, and usually the second molt. In large squash buds and blossoms (Fig. 6) the worms frequently become full grown and do not emerge until ready to pupate. In the smaller buds of cantaloupes and cucumbers they often feed until about half grown, and then move to the fruit. In other cases they burrow from the terminal bud clusters down into the stem and there complete their growth. In other words, these worms are nearly always feeding where poisons applied to the surface of the plant would not reach them.

During normal July or August weather, the rate of larval development is from twelve to sixteen days from the time of hatching to pupation. The last two to three days are spent in completing the lining to their pupal home, which is generally a curled up portion of a leaf, and in resting before assuming the pupal stage. As a general rule larvæ cease feeding three days after passing their fourth molt, spend a part of one day in constructing their cocoon, and then rest for a day or two before assuming the pupal stage.

In the following table is shown the rate of development in relation to the number of instars, which are marked by the molting of the skin which occurs five times.

1st Instar.—From hatching to 1st molt requires about $2\frac{1}{2}$ days.	
2d Instar.—From 1st molt to 2d molt requires about 2 days.	
3d Instar.—From 2d molt to 3d molt requires about 2 days.	
4th Instar.—From 3d molt to 4th molt requires about $2\frac{1}{2}$ days.	
5th Instar.—From 4th molt to 5th molt (changing to pupa) about	5 days.

Average time for hatching to date of pupation about 14 days.

The above is an average time required by the pickle worm to grow to maturity and change to the pupal stage. This estimate was determined by observing and recording the rate of growth of about fifty individuals of which the individual record of fourteen is shown in the following table:

DURATION OF LARVAL AND PUPAL STAGES. *

(Nearly all the molts and emergence of moths occurred at night. Dates below refer to when molts and moths were found.)

Record No.	Date of Hatching.	Date of First Molt.	Date of Second Molt.	Date of Third Molt.	Date of Fourth Molt.	Date of Making Cocoon.	Date of Fifth Molt. (Pupation.)	Total days of Larval Stage.	Total days of Pupal Stage.	Moth Emerged.
2	August 9	August 11	August 14	August 17	August 20	August 23	August 25	16 days	8 days	September 2
3	August 10	August 12	August 14	August 16	August 18	August 22	August 24	14 days	8 days	August 31
6	August 10	August --	August 14	August 15	August 17	August --	August 22	12 days	10 days	August 31
9	August 11	August 13	August 15	August 17	August 19	August 23	August 24	13 days	8 days	August 31
13	August 12	August 14	August 15	August 17	August 19	August 23	August 24	12 days	9 days	September 2
16	August 13	August 15	August 17	August 19	August 21	August 24	August 26	13 days	8 days	September 3
19	August 13	August 15	August 17	August 19	August 22	August --	August 27	14 days	Died	-----
25	August 20	August 22	August --	August 25	August 28	August 31	September 1	12 days	10 days	September 11
26	August 21	August 24	August 26	August 28	August 30	September 3	September 5	15 days	10 days	September 16
29	August 21	August 24	August --	August 27	August 29	September 4	September 5	15 days	10 days	September 15
31	August 22	August 24	August 26	August 28	August 30	September 4	September 5	14 days	11 days	September 16
33	August 21	August --	August 25	August 27	August 29	September 2	September 3	13 days	11 days	September 14
34	August 22	August 24	August 26	August 28	August 30	September 2	September 4	13 days	10 days	September 14
35	August 22	August 25	August 27	August 29	August 31	September --	September 6	16 days	11 days	September 17
Averages ----								13.5-7 days	9.7-13 days	

* Record made in 1902.

From the above table it is seen that the larvæ take from twelve to sixteen days to reach maturity and pupate. Fourteen days is certainly a fair average for all the individuals whose record was secured. Later in the season when cooler weather prevails the development is considerably retarded. Scarcity of suitable food also induces much slower growth.

Pickle worm larvæ are readily recognized until after the fourth molt by the transverse rows of blackish corneous areas from which the setæ arise. When the worms molt the fourth time, these spots disappear almost completely to the unaided eye, and the worms assume a rather uniform greenish or yellowish color, depending on the character of their food. Within one or two days after the fourth molt most of the worms assume a dull coppery color above, soon after which they cease to feed and commence to prepare their pupal home. The increase in the size of the worms after the fourth molt is often remarkable. Some of them more than double in size. This increase is both in length and thickness, but particularly in the latter respect.

The coppery color of most of the full grown worms, serves to distinguish them from the melon worm, *D. hyalinata*, which lose their characteristic white stripes a few days after the fourth molt, but never assume a coppery color.

The older pickle worms, when feeding on cantaloupes, readily pass from one plant to another or from one fruit to another, thus injuring several cantaloupes, particularly when these are nearly ripe. In summer squash they are more liable to bury themselves in the flesh and feed until grown. The same is true when they are feeding in large squash buds or blossoms. Since they show a decided preference for squash buds and blossoms, as well as the squash itself, the grower can protect his cantaloupes to a great extent by using squash plants as a trap crop.

FORMATION OF PUPAE.

The pupal stage is nearly always assumed in the fold of a leaf of the plant on which the pickle worm reached maturity. Sometimes the pupæ are formed in trash around the plants, and occasionally they are not enclosed in anything except the thin silken cocoon that usually lines the place in which they pupate. Evidently all the pupæ are formed above ground. Underneath badly infested squash plants, one may often find fifteen or twenty pupæ in rolls of the leaves which have dropped to the ground. It is much more difficult to find the pupæ around cantaloupe plants.

The duration of the pupal stage during the early part of September is shown on page 116, the average being practically nine and one-half days. This, however, is longer than the average time for July and August. In addition to the record on page 116, the

duration of the pupal stage was determined for sixty-one individuals between July 30 and August 17, 1909. Of this number three pupated in seven days; twenty-two pupated in eight days; twenty-six in nine days; and the remainder in ten days. The average duration of the pupal stage for those sixty-one individuals was only 8.83 days, hence nine days may be considered a fair average for the month of August, or during the usual warm summer weather.

LENGTH OF LIFE CYCLE.

Normal Summer Weather.

Individuals of each generation of pickle worms show considerable variation in the time required to reach the adult moth stage. The possible extremes are shown by the following figures, taken from previously recorded records.

SHOWING POSSIBLE VARIATION IN LIFE CYCLE OF PICKLE WORM.

Minimum Life Cycle.		Maximum Life Cycle.	
	No. Days.		No. Days.
Egg stage.....	4	Egg stage.....	4
Larval stage.....	12	Larval stage.....	16
Pupal stage.....	7	Pupal stage.....	11
Total.....	23	Total.....	31

The average life cycle, as shown by all records secured, is twenty-seven days as the above figures indicate. Adding to this about one week for the moths to mate and commence to deposit eggs, it appears that the generations may follow each other about every thirty-four days, or a little over one month.

HOW WINTER IS PASSED.

The pickle worms pass the winter as pupæ under or around their food plants. Probably some few crawl a short distance before pupating, but no pupæ have been found by the writer at a greater distance than about ten feet from the food plants. During the latter part of September, 1909, a late cucumber field literally riddled by pickle worms, was frequently visited for the purpose of securing worms and pupæ. There the pupæ were often found on weeds several feet from the infested vines, and would have passed the winter in that situation, had they not been destroyed.

As a remedial measure, the burning of remnants of infested plants, and the weeds and trash around these plants, is undoubtedly of great value. It should be remembered, however, that many of

the pupae are in the folds of the leaves that have fallen on the ground, and most of these will be left if the plants are simply pulled up. In other words, the trash under the plants should be raked together and burned.



b

FIG. 7.—Pickle Worm Injury to Young Squash. (a), showing practically natural appearance as seen in field; (b), same specimen cut in halves. Worms of all ages were working on this specimen. About $\frac{1}{2}$ natural size. (Original.)

SEASONAL LIFE HISTORY AND GENERATIONS.

The time of appearance of the moths in the summer, from the over-wintered pupæ, is, fortunately, very late compared with many insects. In 1909, at Raleigh, moths of the first generation were discovered in the field on August 5, but empty pupæ shells were found on July 30. Judging from the condition of the worms present at that time it seems that these moths could not have emerged many days before the empty pupal shells were discovered. Granting this to be true, the eggs for this generation were laid about as early as July 1, or possibly a few days sooner. Without other records for comparison, one would judge the first generation to have commenced about July. However, in 1910, which was considered a much later season than 1909, live pupæ were found on squash plants near Raleigh on July 6, showing that the first generation in 1910 certainly commenced rather early in June.

On the following day, July 7, seven egg masses were discovered, and these hatched on July 10 and 11. Since frequent search for eggs had been made during the previous month, and none discovered, it seems quite certain that these may have been laid by an early maturing moth of the first generation.

It appears certain, therefore, that the first generation in 1909, the progeny of moths emerging from over-wintered pupæ, were missed absolutely and the empty pupæ shells found July 30, 1909, must have represented moths of the second seasonal generation.

The writer is confident that the first generation at Raleigh commences early in June for most seasons. The first generation must of necessity be very few in numbers, and easily overlooked. The manner of passing the winter shows that only a few pupæ would ordinarily survive the plowing and preparation of the land during winter or spring, followed by more or less cultivation before June 1, when the first moths may appear.

The second generation, commencing early in July is the one that frequently does some damage to cantaloupes which are maturing about July 15 to 30, but when the crop is gathered before July 15, as it is in early seasons, and especially in the cantaloupe section of Robeson and Scotland counties, pickle worms can not become numerous enough, or large enough, to cause noticeable injury. The season of 1910 was notoriously late and backward. Cantaloupe growers in Robeson County who usually commence to harvest the crop by July 4, did not commence until after July 15, and growers in that section claim that they saw more worm injury in 1910 than in many previous seasons.

The third generation always becomes very numerous and destructive. Cantaloupes that ripen after about August 1 are invariably greatly damaged. In the vicinity of Raleigh in 1910 this August

injury amounted to almost total destruction in fields where squash was not present to act as a trap crop.

A full fourth generation occurs in North Carolina, but after the first one the generations are hopelessly missed and over-lapping. With sufficient food supply and warm October weather a fifth generation very probably occurs. Around Raleigh pickle worm moths continue to emerge until the latter part of October, but seldom later.

NATURAL ENEMIES.

The pickle worm does not have any important parasitic enemies in North Carolina, judging by the last two seasons work by the writer. Out of the hundreds of worms collected from the field and bred to maturity no true parasites have been reared with the exception of *Chalcis ovata*, and only one of these has been secured. This chalcid fly was also reared from a pickle worm pupa, by Ashmead, as recorded in Bureau of Entomology Bul. 14. No egg parasites have been secured. Out of several hundred eggs collected from the field, only a very few failed to hatch, and even that small per cent did not appear to be parasitized. A bacterial disease kills



FIG. 8.—Predaceous Enemy of Pickle Worm. (a), view from above; (b), from beneath; (c), from side. Magnified $2\frac{1}{4}$ times. (Original.)

annually a small per cent of the nearly mature worms in the field, and in breeding jars a still greater per cent die from that cause.

Predaceous insects kill a small per cent of pickle worms. In fields about Raleigh the tiger beetle, *Calosoma calidum*, and several ground beetles, such as the common black form, *Harpalus caliginosus*, as well as bombardier beetles of the Genus *Brachinus*, are quite numerous and doubtless prey upon the pickle worm. The writer has never seen any of these predaceous beetles actually killing the pickle worm, but they are probably of some value in this respect.

A predaceous larva of the genus *Chauliognathus* has been found

in large numbers and has proved to be an active enemy of the pickle worm. The parent form is known as the Pennsylvania soldier beetle, which somewhat resembles the common firefly. The velvety dark brown or black larvæ were first observed in rather large numbers



FIG.—Pupæ and Adult of Larvæ shown in Fig. 8. (a), pupa recently formed; (b), pupa darker colored, nearly ready to transform to adult; (c), adult beetle. Magnified $2\frac{1}{4}$ times. (Original.)

in 1909 and were reared to maturity in 1910 and identified by Schwartz as *Chauliognathus Pennsylvanicus*. (Figs. 8 and 9.)

In this vicinity this larva appears to be the most important predaceous enemy of the pickle worms. It is also of great benefit to the agriculturist by destroying other worms.

PREVENTIVE AND REMEDIAL MEASURES.

Avoiding pickle worm injury by raising early crops of cantaloupes, cucumbers, or other cucurbits, is the most profitable method for the market gardener. Previous to July 1, in all except the coastal section of North Carolina, the worms are seldom numerous enough to cause noticeable injury, but when the harvest comes during July and August severe damage may be expected. After the worms first commence to feed on the green or ripening fruit, the grower has no satisfactory means of fighting this pest. No absolute remedy is available. Such measures as collecting the worms by hand, bagging the fruit, or placing the fruit on chips and shingles may be of some value in small garden patches, but can not be adopted by the commercial grower. However, a large proportion of the annual loss may be prevented by growing summer squash as a trap plant, by destroying badly infested vines and fruit, and by general clean culture and deep plowing. Poison sprays are of little, if any value, against the pickle worm.

Squash as Trap Plant. Pickle worms evince a decided preference for the buds, blooms and fruit of summer squash. The egg-laying moths are evidently attracted by the large plants and conspicuous buds and blooms, which afford abundant food for the worms. A single squash bloom often furnishes food for two or three large pickle worms (Fig. 16), or a greater number of small ones, while several worms may mature in a small squash. Their partiality to squash blooms was demonstrated in Georgia during 1899-1901, by Quaintance,¹ whose field experiments proved that an acre of cantaloupes might be almost completely protected by four rows of summer squash. One of his experiments, made in 1901, was with one acre of cantaloupes, in which squash seed were planted at intervals of about two weeks, so that there was a succession of blooms from early in June, through July, by which time the cantaloupes had about all ripened. As the squash blooms became infested with worms, they were regularly collected, and the number of worms counted. The record shows that the number collected, commencing June 19, and ending July 30, was 5,519, or an average of over 131 worms each day. On the date of July 13, 1,289 larvæ were found in the infested buds and blooms. On the day following, July 14, a careful search was made for infested cantaloupes, and only six were found that had been bored into, out of hundreds then to be seen in the field.

During 1909-10 the writer made careful observations in many cantaloupe fields near Raleigh, all of which prove that wherever summer squash are growing beside of, or among cantaloupes, the latter are protected from pickle worms to a great extent. Especially in 1910, the value of squash as a trap plant was thoroughly demonstrated. A very conclusive test was made at the State Hospital Farm, where three or four acres of cantaloupes are regularly grown. In the spring of 1909, at the writer's suggestion, a few summer squash were planted among the cantaloupes, and resulted in a material reduction of pickle worm injury, compared with the 1908 crop.

Only one planting of squash seed was made, at the same time as the cantaloupe seed, and the squash plants were practically ruined by the worms before the middle of August, while for three weeks previous to that time, the few squash plants did not furnish enough attractive buds and blooms to protect the cantaloupes.

In 1910, however, seven rows of squash were planted the entire length of a rather long three acre field of cantaloupes. It was intended that the squash seed should be planted two weeks later than the cantaloupes, to provide abundant bloom during the latter part of June, but owing to the unfavorable season, the seed had to be replanted two and three times, and it was July 1, before many squash plants commenced to bloom. On July 7, the first infested bloom, containing ten very young worms, was discovered. No worms could

¹ Ga. Sta., Buls. 45 and 54.

then be found on the cantaloupes. The next careful examination, made July 15, showed that the squash buds and blooms were becoming considerably infested. Three hills of squash (each containing two plants) were selected, at random, and carefully examined with the following result:

On first hill found	29 larvæ of various ages.
On second hill found	24 larvæ of various ages.
On third hill found	9 larvæ of various ages.

Total for 3 hills	62 larvæ of various ages.
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Five egg masses were also taken from these three plants.

In the entire seven rows of squash, there were, in round numbers, 400 hills, all infested to about an equal extent. By allowing for only twenty larvae for each hill, it appears that the field contained, on July 15, about 8,000 pickle worms of all ages.

The cantaloupes were also carefully examined on July 15, with the result that not one was found that had been eaten into, and no larvæ or eggs were discovered on the buds or blooms.

This field was again visited and a record made on July 27, when it was evident even from a casual examination, that the squash plants were becoming badly infested with pickle worms. Three hills were again selected at random, and examined with the following result:

On first hill found	58 larvæ of various ages, and	8 pupæ.
On second hill found	92 larvæ of various ages, and	6 pupæ.
On third hill found	28 larvæ of various ages, and	2 pupæ.

Total for 3 hills	178 larvæ of various ages, and	16 pupæ.
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Egg masses representing over 30 eggs were also found on the three hills.

These three hills represented the average condition of the entire 400 squash hills. Counting both larvæ and pupæ, the average number on this date for each hill was practically 65, or the enormous number of 26,000 for the entire field.

A thorough search over the cantaloupes, especially in rows adjoining the squash plants, revealed only one in which a hole had been bored. Doubtless some small larvæ were overlooked, but there was no apparent injury. Cantaloupes in this field were just commencing to ripen, while in early seasons, the crop would have been largely harvested.

The above record demonstrates the possibilities of summer squash, as a trap plant, and also shows that such plants should be systematically searched, and infested buds and blooms destroyed, if the pickle worms are to be prevented from increasing. The record really

speaks for itself. In this instance nothing was done to destroy the worms. The writer had permission to enter and examine the field at all times, but his suggestion that the infested squash plants be entirely removed and destroyed, was not followed.

On August 1, about two per cent of the cantaloupes in this field were infested with pickle worms, and from that date the injury gradually increased, until on August 12, the damage amounted to fully ten per cent.

On the same date a cantaloupe field near Method, about two miles from the State Hospital farm, was practically ruined and presented a pitiful spectacle of maturing cantaloupes utterly worthless. This field had no squash plants near by. A similar situation was observed in a field at Garner, five miles from Raleigh, and numerous other observations might be recorded, if necessary.

Successive planting of squash seed, about every two weeks, in order to provide plants with abundant buds and bloom during July and August, would doubtless enable one to raise cantaloupes for August consumption, provided the infested squash buds and blooms, and infested squash also, were collected and destroyed during July. It is the moths maturing after about July 15th that are responsible for the destructive July and August generations.

Concerning the practicability of growing summer squash with cantaloupes, without injuring the quality of the latter, there seems to be no question. Some cross-fertilization doubtless occurs, and the seed from a crop grown in this manner should not be used for planting. For seed purposes cantaloupes should be grown where they are not liable to cross with any other cucurbits.

The labor required to collect infested squash blooms is an important item, but in actual practice it could be largely avoided, while still securing the desired result, by successive plantings, and total destruction of infested squash plants before many worms reached maturity in the blooms or fruit.

Destroying Infested Plants After Harvest.—Complete removal and destruction of all infested plants and worthless fruit immediately after the crop is gathered, will serve to destroy many hundreds of pickle worms in all stages of development, and thus prevent, or lessen, the natural increase. Such work does not help the current crop, but will lessen the numbers for the following season. Plants may be destroyed by feeding to hogs, or by burning, or by means of a compost heap.

The compost heap furnishes a valuable method of disposing of remnants of garden crops, as it produces a manure that most soils require. As a means for destroying insects like squash vine borers, melon worms, pickle worms, and others, the compost heap may prove as effective as fire if the infested material is packed down and covered with earth, or decomposed compost, in order that the heat gener-

ated by the rotting organic material in the pile may destroy the larvæ and pupæ or imprison the adults which sometimes emerge from their cocoons a few days after the material is piled. Many moths may mature and escape from cucurbit plants which are gathered and dumped loosely in a pile. Burning would be better, unless the material is worked into compost as suggested. Diseased vines should always be burned, regardless of the waste in fertilizing material.

Deep Plowing and Rotation.—Turning the land by deep plowing immediately after a crop is gathered, or else in the early fall, or even during winter or spring, will serve to bury the pickle worm pupæ, and imprison most of the emerging moths. Early fall plowing is of most value, for it prevents the late generations, or at least greatly lessens their numbers.

Rotation is of some value, but by no means a certain preventive measure. It is not advisable to plant cucurbits on land that has borne infested crops the previous season, although pickle worm moths fly for considerable distances.

Poison Applications.—Poisons are mentioned last, because, in the writer's opinion, they are of little value against pickle worms. Poison dusts or sprays applied liberally to trap plants, or even to the main crop, may serve to destroy a few young larvæ that feed on the leaf buds or unopened blooms, especially when plants are badly infested, but the practice can not be recommended, except when the true melon worms are present. The latter may be poisoned more easily because of their habit of feeding freely on the foliage, as explained in the following pages.

MELON WORM.

Diaphania hyalinata. Linn.

REASON FOR COMMON NAME.

This insect is commonly termed the melon worm, although it has been referred to by different writers as the melon caterpillar, cucumber borer, squash borer, and even the pickle worm, which is now generally accepted as the common name for *Diaphania nitidalis*. The name, borer, in connection with this worm, is not exactly proper, since the worms frequently feed entirely on the foliage. At any rate, it seems best to retain the above common name, because by that term it is known by most farmers. Striped melon worm would be a very descriptive term to distinguish it from the prominently spotted pickle worm.

FOOD PLANTS AND FEEDING HABITS.

Plants belonging to the cucurbitaceous family represent the food of melon worms so far as the writer can ascertain. Squash, cymlin,

cashaw or summer crook-necks seem to be the favorite food, but cucumbers, cantaloupes or muskmelons, gourds, pumpkins and watermelons may be attacked by them. The writer has never seen these worms in watermelon vines or on the fruit, but there are one or two records of such injury. Around Raleigh the principal injury occurs on summer squash, but in their absence cantaloupes and cucumbers are the favorite food plants.

Observations made during the past two seasons, principally around Raleigh, indicate conclusively that melon worms, until they become numerous, feed mainly on the foliage of summer squash, if available. When feeding on cantaloupes and cucumbers the fruit may be attacked to a serious extent, probably because the foliage of these plants is not as acceptable as that of summer squash. In States southward, where melon worms sometimes become numerous during July, which they do not around Raleigh, injury to the fruit of squash, cantaloupes and cucumbers is very serious, even though the first generation at least prefer to remain on the foliage.



FIG. 10.—Squash Foliage Badly Eaten by Melon Worms Which Feed From the Under Surface of Leaves. Photograph taken in field. (Original.)

Larvæ only a few days old are generally found feeding in the opening bud clusters, or on the tender young leaves. While feeding they are usually slightly protected by a thin, thready web. As the worms become larger, this web is often quite noticeable on the under side of the leaves, and serves as a retreat for the worms when not feeding. Evidently most of the active feeding occurs at night, or at least after the hot portion of the day. Many worms attain full growth on the foliage, and, when numerous, cause severe defoliation, as shown in Fig. 10.

Actual injury to summer squash, cantaloupes and cucumbers is usually caused by the half-grown or nearly mature worms. Younger worms may excavate shallow cavities in the rind, or penetrate sufficiently to cause the fruit to decay. The older worms, usually bore directly through the rind, while in cantaloupes that are ripening a single worm may make several entrance holes.

Melon worms differ from pickle worms in seldom, if ever, going into the leaf stems or stalk to feed, and as a general rule, in the vicinity of Raleigh they will nearly defoliate the food plants before causing much damage to the fruit. Reports from the more Southern States indicate that the melon worms feed to a greater extent in the ripening fruit; but that habit is doubtless due to their greater numbers in those States.

HISTORY AND DISTRIBUTION.

The melon worm was first described under the name *Phalæna hyalinata* by Linnæus in 1767, but writers since that date have used the names, *Pyralis hyalinata*, *Phakellura hyalinatalis*, *Eudiotis hyalinata*, *Margaronia hyalinata* and *Diaphania hyalinata*. Most recent writers have placed it in the Genus *Margaronia*, but in Holland's Moth Book it is referred to as *Glyphodes hyalinata*, with synonyms, *marginalis*, Stoll, *lucernalis*, Hubner, and *hyalinatalis*, Guenée. It is to be hoped that *Diaphania hyalinata* will henceforth be the accepted scientific name.

The earliest mention and description of the melon worm moth was made by Linnæus in 1767. Fabricius listed it in 1794, giving its habitat as America and Asia. Poey, in 1832, published an article with a colored figure of the larva and pupa. In 1854, Guenée gave a very good description of the moth, and its distribution, together with food plants of the larvæ. Since 1875, when this insect was mentioned by Dodge as destructive to cucumbers in Florida, it has received frequent mention by various writers. During 1878-1879 the melon worm was a very serious pest in Georgia and furnished a topic for considerable discussion at the Fifth Meeting of the Georgia State Horticultural Society, held in Atlanta in 1880. During that year it was determined that the melon worms did not seriously injure cantaloupes until August, while the pickle worm was destructive in July, a condition that is generally true at the present time. Lintner, in the 11th Report of Insects of New York, 1895, gave a good general account of the melon worm, together with the bibliography to that date. Since then it has received prominent mention at the hands of Chittenden, Quaintance, Garman and others, sufficient to make it rank as a very important insect pest.

The known distribution of the melon worm includes Brazil, Hayti, Colombia, French Guiana, West Indies and Canada. Chittenden thinks melon worm to be of South American origin.

In the United States, it is more or less abundant and destructive in all the Atlantic and Gulf States from the District of Columbia, southward and westward to Texas, inclusive. It is known also in Illinois, Kansas, Ohio, Michigan, New York, New Jersey, Pennsylvania, Maryland, Delaware, and doubtless occurs in many other of the Northern and Western States. Only in the Southern States, however, is this species counted as a destructive pest. In North Carolina it does not compare in extent of injury with the pickle worm. In the opinion of the writer, this State represents about its northern range as a very destructive insect.

DESCRIPTIONS.

Eggs. (Fig. 11.)

Individual eggs are flattened, more or less oval, iridescent pearly white in color when first deposited, very thin shelled so that they assume various shapes, and are laid in masses of from two to five or six. Only occasionally are eggs deposited singly. The surface of the shell is faintly marked with raised, irregular, four, five and six-sided areas. In every respect they resemble the eggs of *Diaphania nitidalis*. When about one day old the eggs commence to assume a

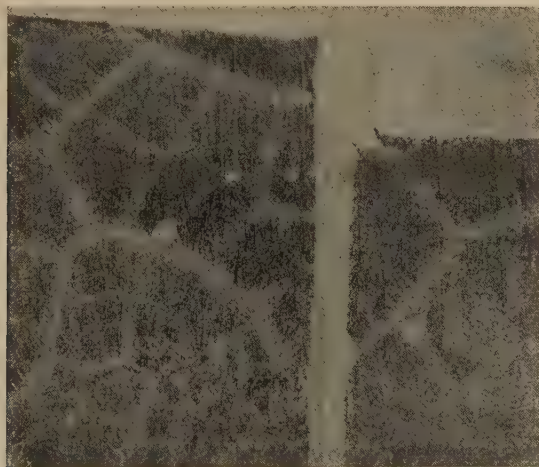


FIG. 11.—Two Egg Masses of Melon Worm on under surface of leaf. Magnified 5 times. (Original)

yellowish tinge, which becomes more noticeable as the larva within develops. Before hatching, the outline of the larva with its light brown mandibles, can be seen through the nearly transparent shell. At this stage one might possibly distinguish eggs of *D. hyalinata* from *D. nitidalis*, because the head of the latter is darker and appears more distinct through the shell. A single egg measures about 0.7 mm. in length and 0.6 mm. wide, but is variable, depending on where and how it is placed.

Larvæ.

First Stage.—Length when first hatched, 0.8 to 1.0 mm.; width of head 0.22 mm. Body, light straw color; setæ, very fine and nearly colorless, arising from tubercles arranged as in first stage of *D. nitidalis* (page 109); tubercles barely discernible; head light brown, with mandibles darker and toothed; ocelli brown-

ish; prothoracic shield not prominent, lighter than head. Thoracic legs well developed. Prolegs well developed and normal, ending in circlet of many incurved hooks (numbering nearly forty in second stage). In this first stage the two white stripes, characteristic of the melon worms, are not discernible. The body tapers noticeably from the head posteriorly in very young larvæ. Length of the worm is nearly doubled before first molt.

Second Stage.—Length about 2.6 mm., variable. Head about 0.37 mm. wide; light brown. Ocella, blackish; mandibles dark brown. General color of body yellowish, with rather transparent skin, through which may be seen the pulsations of dorsal blood vessel. Color greenish yellow after feeding. Two sub-dorsal white stripes, extending entire length of body, show faintly just after first molt, and become prominent before second molt. Body tapers slightly caudad. Thoracic legs normal, well developed. Setæ of varying lengths arising from distinct conical areas, that are smooth and shiny, but not conspicuous to naked eye. Setæ very slender, colorless.

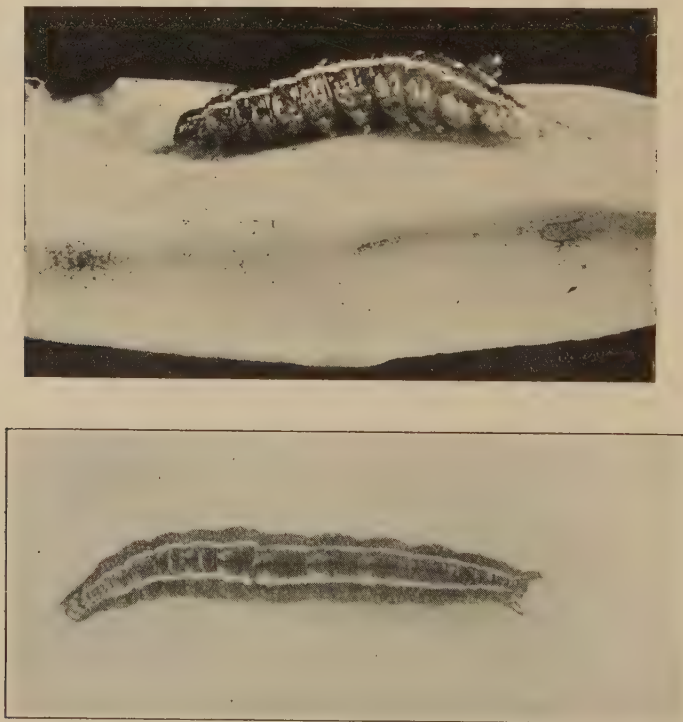


FIG. 12.—Melon Worms Photographed Alive on Piece of Cimblin. Specimens practically full grown. Magnified $2\frac{1}{2}$ times. (Original.)

On the third abdominal segment the arrangement of tubercles and setæ in this and succeeding larval stages is as follows: Tubercle I, on inner edge of each sub-dorsal white stripe, bearing one long seta; Tubercle II, caudad of I, in center of each white stripe, bears one seta one-half as long as seta of Tubercle I and III. Tubercle III, in direct line with Tubercle I and spiracle, and situated one-fourth of the distance from latter, bears one long seta, about same length as seta of Tubercle I. Tubercles IV and V very close together, apparently forming one conical area, but showing distinct tubercle for each short seta; approximately in line with Tubercles I, III and spiracle. Setæ short, but slightly longer

than seta of Tubercle II. Tubercle VI, posterior-ventrad of IV and V, situated just above base of proleg; bears one seta, rather long, but shorter than seta of Tubercle I. Tubercle VII, on outer base of proleg, bears three setæ arising close together, one of which is much longer than the other two. Tubercle VIII, on inner base of proleg, bears one short seta. This arrangement of tubercles is the same on the third, fourth, fifth and sixth abdominal segments. On segment eight, the setæ of Tubercle VII are more separated and Tubercle VIII is absent. On segment nine there are only two setæ on Tubercle VII.

Before second molt the body increases in size to a width greater than the head, which then appears small.

Third Stage.—Length about 4.5 mm., variable. Head about .64 mm. wide; color, light brown. Ocella, blackish, mandibles brownish. General color of body greenish-yellow after feeding. Two subdorsal white stripes very prominent. Setæ fine and not easily seen. During the third and fourth and part of the fifth stage the white stripes make this worm noticeable, and easily distinguished from *D. nitidalis*, on which the transverse rows of blackish corneous areas are very prominent until after the fourth molt. Growth is rapid in this stage, so that just before third molt the head appears very narrow.

Fourth Stage.—Length about 10 mm., variable. Head about 1.04 mm. wide; color, light brown. Prothoracic shield light brown, not prominent. Ocella, blackish. Body yellowish, with skin almost transparent, so that the character of the food taken influences its general color. Growth rapid. Conical tubercle areas smooth; shiny light green in color, but not conspicuous. Setæ as in second stage.

Fifth Stage.—(Soon after fourth molt.) Length about 16 mm., but capable of much extension or contraction. Head averages 1.63 mm. wide. Color of head light brown, mandibles darker brown, ocella blackish. General body color yellowish prior to feeding, and two subdorsal white stripes still prominent. The larvæ now appears slender, but increase rapidly in length and thickness until, when full grown, some measure one and one-fourth inches when crawling about. Usual color is a mottled greenish-yellow. Edges of the white stripes rather irregular. Within from two to five days after fourth molt the white stripes commence to grow fainter and usually disappear about the time when the larvæ cease to feed. In some specimens these stripes almost completely disappear two days after fourth molt, while with others they persist until six or seven days after fourth molt, or just prior to pupation.

Full Grown Larvæ.

The length of full grown melon worms varies from three-fourths to one and one-fourth inches, this measurement depending largely on whether the larvæ are contracted, as when disturbed, or extended when crawling about. The general greenish-yellow color of the body is retained while the larvæ are feeding. They never assume the coppery color, characteristic of most of the full grown pickle worms. If taken just prior to pupation the melon worms are readily distinguished from pickle worms, by having a much lighter brown head, longer and more slender setæ, rather more slender body, and no sign of coppery color above. Shortly before transforming to the pupal stage, melon worms contract to about five-eighths of an inch in length and change to a light yellow or straw color.

Cocoons. (Fig. 13.)

The cocoon is formed by the grown larva spinning a scanty lining of whitish silken threads, usually in the folded or rolled edge of



FIG. 13.—Melon Worm Pupa in Web or Cocoon. Pupa in upper cut, entirely exposed; lower one, nearly natural appearance. Magnified $2\frac{1}{2}$ times. (Original).

some leaf. In the laboratory, in glass vials, the larvæ spin a net work of silken threads in which they are suspended. In this meagre protection the pupal stage is passed.

Pupæ. (Figs. 13 and 14.)

Average length about five-eighths of an inch. Color very soon after pupation is very light brown with head and posterior end darker. Leg shields separate, extending to ninth segment. Head rather acutely pointed, somewhat flattened, dorso-ventrally. Caudal end acute and bearing a group of a few stiff spines with strongly curved tips, which serve to secure the pupa in its web or cocoon.

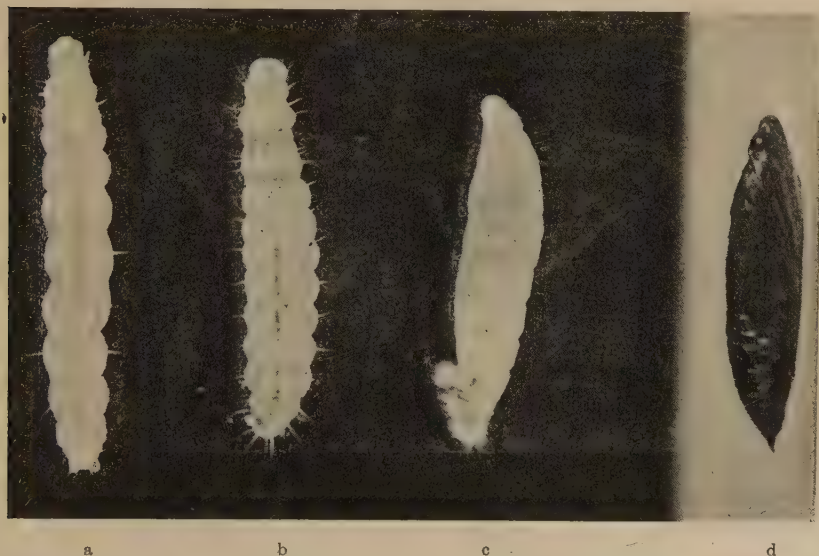


FIG. 14.—Melon Worms and Pupæ. (a), larva, fifth stage, still showing white stripes; (b), larva, fifth stage, after losing stripes; (c), pupa just formed; (d), pupa, natural color. Magnified about $2\frac{1}{2}$ times. (Original.)

General color of pupa changes to brown after a few hours, and when not well protected from the light they become very dark brown, sometimes almost black. Leg shields usually remain light-brown. Spiracles show prominently before the pupa becomes dark colored. Comparing melon worm pupæ with those of the pickle worm, the former have a longer and more flattened head, and longer leg shields. They also present a rather more slender appearance, but on the whole the two species are very similar.

Adult Moths. (Fig. 15.)

The moths into which melon worms develop present a striking appearance. Width of the expanded front wings of large individuals is nearly one and one-fourth inches, while small ones measure less

than one inch across; length from tip of head to tip of prominent brush terminating the abdomen is about nine-sixteenths of an inch. The front wings are of a pearly, opaque whiteness, with a peculiar iridescence, and have a broad costal band, and border equally wide, of a shining iridescent brown; the hind wings are of the same color with a brown border, diminishing toward the anal angle, which it does not reach. The anterior half of the thorax above has the same shining brown color as the wing border, while the posterior portion



FIG. 15.—Melon Worm Moth. Magnified $2\frac{1}{2}$ times. (Original.)

of the thorax and the abdomen above is pearly white, except a shining brown dorsal spot on the last segment. From beneath, the general color of body, legs and wings except the border, is silvery white.

The conspicuous anal brush is formed of shining, elongated flattened scales, which have the basal half of a yellowish color, and the tips showing a mixture of white, brown or nearly black. This brush can be partly withdrawn, or quickly expanded to twice the width of the abdomen. The moths usually wave the expanded anal brush up and down and sideways, holding the abdomen turned slightly upward.

EGG LAYING AND HATCHING OF EGGS.

Eggs are laid rather promiscuously on the terminal bud clusters, stems, tender leaves, or sometimes on the main stalk of summer squash and cantaloupe. They have apparently never been found on the fruit. From two to six eggs are laid in masses of irregular shape, sometimes on the large plant hairs, but more commonly flat on the surface of the bud or leaf. When on the latter they are

found underneath. An attempt was made in 1909 to determine the manner and time of egg laying by confining moths in a large wire screen cage, but nothing definite was learned by this attempt. The eggs are undoubtedly deposited at night, although the moths frequently fly about during the day.

Eggs hatch in warm summer weather in from three and one-half to four days. A few hours before hatching the larva may be quite plainly distinguished through the thin shell and the brown mandibles



FIG. 15.—Showing How Pickle Worms Occur in Squash Bloom.
Natural Size. (Original.)

may be seen opening and closing in an attempt to cut an opening large enough to allow the larva to emerge. When this opening is effected the larva may crawl out within a few minutes, or a much longer time, sometimes nearly an hour.

LARVAL DEVELOPMENT AND HABITS.

Larvæ commence to feed soon after emerging from the egg. Some feed, until nearly or quite fully grown, entirely on the under surface of the leaves, or between the opening buds and tender leaflets, while others bore into the buds after feeding for a day or two on the outside.

Very few larvæ reach the fruit until they have attained, or passed, the third larval stage. Judging from the habits of the larvæ observed on summer squash around Raleigh, they prefer to feed entirely on the green foliage, but when tender leaves are not available, they go to the fruit, where shallow cavities may be eaten in the rind, or holes bored directly toward the interior of the fruit, where the worms feed until grown.

When feeding on the foliage or buds they nearly always spin a thin silken web to serve as a retreat, into which they back when disturbed. The movements of the larvæ of all sizes are very rapid. When disturbed they move quickly backward or forward, and often wriggle about and drop from their feeding place. The natural position of a fully grown larva, in the attitude of walking, is well illustrated in Fig. 12.

When ready to spin their cocoons (Fig. 13), melon worms seek some place between two leaves or else fold over or roll up a portion of the edge of a leaf for protection. Several hours are spent in lining this retreat, which represents the cocoon, after which they take from one to two days to transform to the pupal stage.

The average length of the larval stage is recorded in the following table, showing the development of sixteen specimens, out of over sixty that were fed and watched from the day of hatching until the adult moth appeared. Nearly all the eggs hatched and the worms molted at night, hence the dates recorded usually refer to the previous night.

DURATION OF LARVAL AND PUPAL STAGE.

Rec- ord No.	Date of Hatching.	Date of First Molt.	Date of Second Molt.	Date of Third Molt.	Date of Fourth Molt.	Date of Making Cocoon.	Date of Fifth Molt (Pupation.)	Length of Larval Stage.	Length of Pupal Stage.	Moth Emerges.
	1909									
1	August 12	August 14	August 16	August 18	August 20	August 24	August 25	13 days	7 days	September 1
3	August 12	August 14	August 16	August 18	August 20	August 24	August 25	13 days	7 days	September 1
11	August 13	August 15	August 17	August 19	August 22	August 26	August 28	15 days	9 days	September 6
17	August 10	August 13	August 15	August 18	August 20	August 23	August 24	14 days	8 days	September 11
35	August 20	August 23	August --	August 27	August 29	September 2	September 4	15 days	11 days	September 15
40	August 20	August 24	August 26	August 28	August 30	September 4	September 5	16 days	9 days	September 14
42	August 22	August 25	August 27	August 28	August 31	September 5	September 6	15 days	11 days	September 17
43	August 22	August 25	August 27	August 29	August 31	September 4	September 6	15 days	9 days	September 15
45	August 22	August 25	August 27	August 29	September 1	September 6	September 7	16 days	11 days	September 18
47	August 22	August 25	August 27	August 29	August 31	September --	September 6	15 days	11 days	September 17
51	August 23	August 25	August 27	August --	September 1	September 6	September 7	15 days	11 days	September 18
57	August 23	August 25	August 28	August 30	September 1	September 6	September 7	15 days	11 days	September 18
59	August 23	August 25	August 28	August 29	August 31	September 4	September 6	14 days	10 days	September 16
62	August 23	August 25	August 27	August 28	September 1	September 5	September 6	14 days	11 days	September 17
65	August 23	August 25	August 27	August 29	August 31	September 5	September 6	14 days	11 days	September 17
66	August 23	August 26	August 28	August 30	September 1	September 6	September 7	15 days	11 days	September 18
							Averages-----	14 5-8 days	9 7-8 days	

From the foregoing table the length of the larval stage is seen to vary from thirteen to sixteen days, while the average of the sixteen records is fourteen and five-eighths days. It is probable that a similar record kept one month earlier, provided specimens could have been obtained, would have given a slightly lower average. The weather for 1909, during the latter part of August and September, was a little cooler than during the month of July.

PUPAE AND DURATION OF PUPAL STAGE.

The pupæ, as already stated, are usually formed in a rolled portion of a leaf, or between two leaves of the plant, on which the larvæ feed. On growing squash plants, with abundant foliage, pupæ are commonly formed in the folded edge of a green leaf some distance above the ground, but in old plants the pupæ are usually in a leaf or some vegetation underneath or close by the food plant. As a general rule the worms do not crawl far in search for a suitable place to pupate, although a few specimens have been taken from grass and weeds several feet from squash or cantaloupes. The fact that the worms do not wander far from their food plants is advantageous to the grower who may seek to destroy the worms and pupæ by burning the old worthless plants after the crop is harvested.

Concerning the duration of the pupal stage, the table on page 137 shows the average period between August 31 and September 18, for sixteen specimens, to be almost ten days. This is, however, a longer average period than that recorded for thirty-five pupæ obtained between August 8 and 18, 1909. From that number one moth appeared in seven days, thirteen moths on the eighth day, two moths on the tenth day, and nineteen required only nine days. The average pupal stage for these thirty-five pupæ was practically eight and two-thirds days, or more than one day less than the time shown in table on page 137. From all records secured the duration of the pupal stage for *D. hyalinata* is just about nine days.

LENGTH OF LIFE CYCLE.

From the foregoing records of the duration of egg, larvæ and pupa stages, the entire life cycle for a single generation in normal summer weather, is seen to be quite constant, but with possible variations as given in the following table:

SHOWING POSSIBLE VARIATION IN LIFE CYCLE OF MELON WORM.

Minimum Life Cycle.		Maximum Life Cycle.	
	No. Days.		No. Days.
Egg stage.....	4	Egg stage.....	4
Larval stage.....	13	Larval stage.....	16
Pupal stage.....	7	Pupal stage.....	11
Total.....	24	Total.....	31

The average life cycle proves to be twenty-seven and one-half days during August and September weather, and this length of time will not vary much for any generation except the last. By adding to the above number of days about one week for the moths to mate and commence egg deposition, the generations may follow each other every thirty-three or thirty-four days, until scarcity of food or cold weather retards the development.

HOW THE WINTER IS PASSED.

The winter is passed in the pupal stage, under conditions already described. That is, pupæ that pass the winter are not any better protected than those from which moths emerge during the summer and fall. Evidently the pupæ are always, normally, in a fold of a leaf of the original food plant, or sometimes in grass blades or weeds, within a short distance of where the worms were feeding. Judging from numerous observations made in 1909 and 1910, pupæ that are formed after about the middle of October may live through the winter, while some pupæ formed as early as October 1, do likewise, although moths are occasionally seen here after the middle of October. Some writers have suggested that the moths emerging very late in the fall, November for instance, may live over winter, but it is extremely doubtful if this ever occurs in North Carolina. If that were the case melon worms would certainly appear earlier in summer than is true at present. The over-wintering pupæ do not transform to moths before the following June or later, and it is evident that the great majority must be killed by the usual plowing and preparation of the land in winter or spring, to say nothing of probable cultivation of early crops during April and May.

SEASONAL LIFE HISTORY AND GENERATIONS.

Fortunately for growers of cucurbits, melon worms do not make their appearance until June or July in North Carolina, and seldom earlier than June in the extreme Southern States. In 1909, at Raleigh, melon worms in the second and third stages of growth were present in summer squash fields during the latter part of July, and from a number of pupæ collected August 2 and 3, nearly all of which

proved to be *D. nitidalis*, one melon worm moth was bred on August 7. Two days previous three moths were captured in the field, and for the next two weeks and later moths were occasionally seen, although never more than two or three in a single day. The same year, 1909, at Morehead, Carteret County, many melon worm moths were captured in a cantaloupe field on July 19, and at that date the damage to the crop had been considerable, although much of the injury had been due to pickle worms, which were much more numerous. In 1910, melon worms were not discovered at Raleigh until August 22, when a few in the second stage were found on summer squash. Previous to that date the writer was in cantaloupe, cucumber and squash fields, three or four times each week, after the latter part of May. During that time no melon worm moths were collected, showing that they were certainly very scarce during the season of 1910.

The first generation of melon worms, judging from the record of 1909, must commence about July 1, in the vicinity of Raleigh. That is, about that date, moths emerging from over wintered pupæ, must lay eggs for the first generation. Around Morehead, N. C., in 1909, the first generation commenced as early as June 15, or possibly earlier. In the cantaloupe section of Robeson and Scotland counties there seems to be no record of melon worms before the early part of July even in extremely early seasons. If a generation of melon worms commence in North Carolina before about June 15th they must be extremely few in numbers, and certainly of no consequence.

The second generation at Raleigh in 1909 commenced early in August and at Morehead, fully two weeks earlier. An average date for North Carolina would be the latter part of July. The worms of this generation are the ones that commence to cause noticeable injury to cantaloupe, squash and cucumbers, of the medium late crops. In Robeson and Scotland counties, where the cantaloupe crop is usually harvested about July 10, this second generation never causes noticeable injury. In late seasons, such as 1910, with cantaloupes ripening about two weeks later than usual, the worms might become numerous and destructive.

The third generation is due about the middle of September, but appears too late to injure the valuable portion of the cantaloupe and squash crops. As a general rule cucurbits are dying down at that date. Worms of the third generation must commence to mature early in October and probably the majority pupate and transform to adult moths for a fourth generation, although when the food plants are nearly all dead before October, as is usually true, there is not much chance for a fourth generation, and it is doubtful if a full one develops. Parasites are also very beneficial by destroying many of the mature worms and pupæ of the fourth generation.

All natural forces appear to work against any large number of melon worm pupæ living through the winter, and if the growers of cucurbits will assist nature by destroying the worms and pupæ on and around infested plants, there is no reason why this insect should ever become very destructive.

NATURAL ENEMIES.

During September and October, 1909, two parasites were frequently bred from melon worm pupæ. These parasites were identified by Viereck, of the Bureau of Entomology, as *Amempheres* sp. and *Limnerium* sp. The former was more frequently reared, but both species are of much value and together they destroyed fully one-third of the pupæ secured during October, 1909. These parasites attack the melon worms prior to pupation, but the adults were always secured from melon worm pupæ. Another quite general parasite, a chalcid fly, *Chalcis ovata*, Say, was also reared from the pupæ, in 1909. No other parasites were secured by the writer, but *Pimpla conquisitor* was reared by Comstock in 1879, and is doubtless one of the occasional parasites at the present time.

During the season of 1910, melon worms were few in number around Raleigh, as previously stated, and no parasites were secured from the few specimens that were collected. It appears highly probable that the large number of pupæ destroyed by parasites late in the season of 1909, resulted in a material setback to the melon worms during 1910. There is good ground for the assertion that serious melon worm injury, in this vicinity, is prevented by parasites.

Egg parasites were not discovered, and seem to be unknown for this species.

Predaceous enemies of melon worms may at times prove helpful, especially when the worms are working in the fruit of cucurbits. While they remain on the foliage few are destroyed by the usual predaceous insects, mentioned on page 121. A bacterial disease sometimes attacks and kills the nearly full grown larvæ.

Severe winter weather may be partly responsible for the failure of the melon worms to increase in numbers as rapidly as the pickle worms. It seems probable that natural climatic conditions prevent the melon worm from spreading much farther north, or from being anything worse than an occasional serious pest in North Carolina.

PREVENTIVE AND REMEDIAL MEASURES.

The only remedial measures of value against melon worms consist of possible poisoning for those that eat the foliage, and the use of summer squash to help protect the more valuable crops. The latter is hardly a true remedy, but more in the nature of a preventive measure. Only a brief discussion seems necessary.



FIG. 17.—Row of Summer Squash in Cantaloupe Field, Acting as a Trap for Pickle Worms, (Original.)

Trap Plants and Poison Sprays.—Melon worms apparently show a partiality for summer squash, probably owing to the fact that the egg-laying moths are attracted by the large plants. The worms do not usually occur in the buds and blooms like the pickle worms, but feed freely on the foliage and the maturing squash. Hence these plants may serve as a trap for both species. The writer has always found the melon worm on squash plants before any appear on cantaloupes or cucumbers, and in ordinary years a few squash will serve to trap the earliest worms, allowing cantaloupes or cucumbers to mature before the melon worms injure them to any noticeable extent. This is a fortunate circumstance, in that it allows the gardener to use summer squash as a trap for both species, while by poisoning the foliage and opening buds, many little larvæ may be destroyed before they are many days old.

For a poison spray, arsenate of lead, three pounds to fifty gallons of water, is most advisable, but one-half pound of Paris green with one pound of fresh slaked lime, in fifty gallons of water, may be used. The former is less liable to burn the foliage, and is more adhesive. If poison sprays are employed the trap plants should be thoroughly sprayed, at least three times, at intervals of two weeks, commencing about July 1, in the vicinity of Raleigh, or two weeks earlier in the coastal section of North Carolina.

Such treatment, supplemented by gathering infested buds, blooms, and wormy fruit, as fully discussed on pages 123 to 126, represents the most thorough method of controlling both melon worms and pickle worms.

The application of poison mixtures to a whole field of cantaloupes or cucumbers may be of some value, but it is extremely doubtful if such work would be profitable. The commercial grower can not go to that expense unless the cucurbit vines are attacked by some leaf disease that necessitates the application of Bordeaux mixture or some other fungicide. If any general spraying is made, poison should always be added in the proportion already mentioned.

Disposal of Plants After Harvest.—Prompt cleaning up and removal of remnants of infested crops will help prevent the natural increase of melon worms. This matter is sufficiently explained on page 125, to which the reader should refer.

Deep Plowing and Rotation.—These measures are also explained on page 126 and need not be repeated.

From the Gardener's Standpoint.—In localities where cucurbits have never been damaged seriously by worms, the suggestions given above and on pages 122 to 126 may seem entirely impracticable, but in the vicinity of Raleigh, where the annual loss occasioned by the two insects discussed in these pages sometimes amounts to upwards of fifty per cent, the remedial suggestions are certainly worthy of consideration.

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